

INTERNATIONAL COOPERATION TREATY

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

Commissioner
 US Department of Commerce
 United States Patent and Trademark
 Office, PCT
 2011 South Clark Place Room
 CP2/5C24
 Arlington, VA 22202
 ETATS-UNIS D'AMERIQUE
 in its capacity as elected Office

Date of mailing (day/month/year) 01 June 2001 (01.06.01)	
International application No. PCT/GB00/03491	Applicant's or agent's file reference P23959A/JDB
International filing date (day/month/year) 12 September 2000 (12.09.00)	Priority date (day/month/year) 14 September 1999 (14.09.99)
Applicant VAN DER ENDE, Andre, Martin et al	

1. The designated Office is hereby notified of its election made:

☒ in the demand filed with the International Preliminary Examining Authority on:
 12 April 2001 (12.04.01)

☐ in a notice effecting later election filed with the International Bureau on:

2. The election ☒ was
☐ was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No.: (41-22) 740.14.35	Authorized officer Olivia TEFY Telephone No.: (41-22) 338.83.38
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PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference P23959A/JDB	FOR FURTHER ACTION see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/GB 00/ 03491	International filing date (day/month/year) 12/09/2000	(Earliest) Priority Date (day/month/year) 14/09/1999
Applicant MACHINES (U.K.) LIMITED et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 5 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☐ **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,

☐ the text is approved as submitted by the applicant.

☒ the text has been established by this Authority to read as follows:

APPARATUS AND METHOD FOR MEASURING DEPTH
VERFAHREN UND VORRICHTUNG ZUR TIEFENMESSUNG

5. With regard to the **abstract**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No.

☒ as suggested by the applicant.

☐ because the applicant failed to suggest a figure.

☐ because this figure better characterizes the invention.

1
☐ None of the figures.

INTERNATIONAL SEARCH REPORT

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Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-14

Communication system

2. Claims: 15-35

Downhole depth measurement system

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International Application No

PCT/GB 00/03491

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 E21B47/12 E21B47/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 001 774 A (DAWSON ET AL.) 4 January 1977 (1977-01-04) column 3, line 30 - line 64 column 4, line 19 - line 34	1-13
Y	---	14, 18, 20, 23, 29, 35
Y	US 4 814 548 A (TRAVERSINO ET AL.) 21 March 1989 (1989-03-21) column 1, line 44 - line 46	14
A	US 3 209 323 A (GROSSMAN) 28 September 1965 (1965-09-28) column 5, line 18 - line 37 --- -/--	1

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

28 February 2001

Date of mailing of the international search report

06. 03. 2001

Name and mailing address of the ISA

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Authorized officer

Rampelmann, K

INTERNATIONAL SEARCH REPORT

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 936 461 A (TROSZT) 11 September 1963 (1963-09-11) page 3, line 27 - line 39 page 3, line 79 - line 91 page 4, line 49 - line 57 claim 1	15-17, 19,22, 24,25, 27,28, 30,32-34
Y		14,18, 20,23, 29,35
X	---- US 3 267 365 A (BAKER) 16 August 1966 (1966-08-16) column 1, line 29 - line 35 column 4, line 34 -column 5, line 39 -----	15-17, 19,22, 24,25, 27,28, 30,32,34
X	---- US 3 185 997 A (CARLTON ET AL.) 25 May 1965 (1965-05-25) column 1, line 40 - line 42 column 2, line 32 - line 43 column 2, line 63 -column 3, line 42 -----	15,16, 21,22, 26-28,34
X	---- US 4 044 470 A (DUFRENE) 30 August 1977 (1977-08-30) column 4, line 35 - line 68 -----	22,24

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

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Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 4001774	A	04-01-1977	NONE	
US 4814548	A	21-03-1989	NONE	
US 3209323	A	28-09-1965	NONE	
GB 936461	A		NONE	
US 3267365	A	16-08-1966	NONE	
US 3185997	A	25-05-1965	NONE	
US 4044470	A	30-08-1977	NONE	

10/08/28

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. PCT/GB00/03491

I. Basis of the report

1. With regard to the elements of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*)

Description, pages:

1-37 as originally filed

Claims, No.:

1-35 as received on 11/10/2001 with letter of 11/10/2001

Drawings, sheets:

1/5-5/5 as originally filed

2. With regard to the language, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

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☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

IV. Lack of unity of invention

1. In response to the invitation to restrict or pay additional fees the applicant has:

- ☐ restricted the claims.
☐ paid additional fees.
☐ paid additional fees under protest.
☐ neither restricted nor paid additional fees.

2. ☒ This Authority found that the requirement of unity of invention is not complied and chose, according to Rule 68.1, not to invite the applicant to restrict or pay additional fees.

3. This Authority considers that the requirement of unity of invention in accordance with Rules 13.1, 13.2 and 13.3 is

- ☐ complied with.
☐ not complied with for the following reasons:

4. Consequently, the following parts of the international application were the subject of international preliminary examination in establishing this report:

- ☒ all parts.
☐ the parts relating to claims Nos. .

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims 1-9, 14, 26, 33
	No:	Claims 10-13, 15-25, 27-32, 34-35
Inventive step (IS)	Yes:	Claims
	No:	Claims 1-35

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Industrial applicability (IA) Yes: Claims 1-35
 No: Claims

2. Citations and explanations
see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

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EXAMINATION REPORT - SEPARATE SHEET**

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Reference is made to the following documents:

- D1: US-A-4 001 774
- D2: US-A-3 267 365
- D3: US-A-3 185 997
- D4: US-A-3 209 323

Re Item IV**Lack of unity of invention**

IV-1 Even though none of the independent claims seem to meet the requirements of Article 33(2) or (3) PCT, this International Examining Authority confirms the founding of the International Searching Authority concerning the presence of two groups of inventions in the present application. Said two groups of inventions can be identified as follows:

1. Claims 1-14: Communication system
2. Claims 15-35: Downhole depth measurement system

The "special technical feature" (in the meaning of Rule 13.2 PCT) of the first group of inventions is that the wireline serves as a telemetry link between communications equipment located downhole and communications equipment located topsides. The problem solved by said feature is to provide a way of communication between said mutually remote locations.

The "special technical feature" (in the meaning of Rule 13.2 PCT) of the second group of inventions is to provide depth information for equipment travelling up or down a well by referencing to known locations in said well. The problem solved is therefore how to know the actual travelled distance of a piece of equipment that has been placed inside a well.

The "special technical feature" of the two groups of inventions are therefore different and solve different problems so that no technical relationships can be seen among them. According to Rule 13.2 PCT, the application does therefore not meet the requirement of Rule 13.1 PCT.

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EXAMINATION REPORT - SEPARATE SHEET**

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Re Item V**Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

V-1 D1, which is considered the closest prior art, discloses the subject-matter of claim 1 as follows (the references in parentheses applying to this document):

A communication system for use in a wellbore (col. 1, l. 9-12), the system comprising a downhole tool (21), the downhole tool (21) comprising a transmitter (col. 3, l. 56), the downhole tool (21) being coupled to a wireline (40), wherein the downhole tool (21) and wireline (40) are adapted to be inserted into the wellbore (17), and a receiver (28) located remotely from the transmitter (see fig. 1), wherein the wireline (40) is capable of acting as an antenna for the transmitter (col. 3, l. 57-58).

The apparatus according to claim 1, therefore differs with respect to D1 in that the wireline is also capable of running the downhole tool into the wellbore.

The apparatus according to claim 1 is therefore new and the claim meets the novelty requirements of Article 33(2) PCT.

V-2 The distinguishing feature of claim 1 is thus related the problem of how to more efficiently deploy a device or downhole tool into a wellbore.

In particular, in view of D4, fig. 1, said distinguishing feature of claim 1 does not involve an inventive step in the meaning of Article 33(3) PCT. It is considered obvious that the skilled man would adapt the teaching from D4 into D1 in order to solve the problem.

V-3 Furthermore, D1 discloses the subject-matter of the following claims:

Claim 2: see col. 4, l. 23-24

Claim 3: see fig. 1, item 21

Claim 4: see fig. 1, item 40

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EXAMINATION REPORT - SEPARATE SHEET**

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Claim 5: see col. 3, l. 43-46

Claim 6: see fig. 1, item 28

Claim 7: see col. 3, l. 33-39

Claim 8: see col. 3, l. 58-59

Claim 9: see col. 4, l. 23-24

The subject-matter of said claims does therefore not involve an inventive step (Article 33(3) PCT).

V-4 With respect to independent claim 10, and in addition to what has already been said under section V-1, D1 in fig. 1 furthermore discloses that a wireline 40 including its ends with a transmitter 21 attached to the one of said ends, has in one way or another been payed into the borehole 17. See also col. 4, l. 27-34.

Said claim does therefore not meet the novelty requirements of Article 33(2) PCT in that the claim is not new over D1.

V-5 Also independent claim 11 as well as dependent claims 12 and 13 do not seem to contain novel subject-matter over D1 (see col. 4, l. 19-26). Said claims do therefore not meet the novelty requirements of Article 33(2) PCT).

V-6 The subject-matter of dependent claim 14 is consider an obvious design alternative for the skilled man when solving the problem of insulation material selection. Said claim does therefore not involve an inventive step (Article 33(3) PCT).

V-7 D2 discloses the subject-matter of claim 15 as follows (the references in parentheses applying to this document):

A distance measurement apparatus (fig. 1) for measuring the distance travelled by a wireline (17), the apparatus (fig. 1) comprising at least two sensors (fig. 6, item 64, 65) coupled to the wireline (17) wherein the sensors (64, 65) are capable of sensing known locations (15) in a wellbore (11).

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EXAMINATION REPORT - SEPARATE SHEET**

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The subject-matter of claim 15 is therefore not new contrary to the provisions of Article 33(2) PCT.

The applicants attention is drawn to the fact that even if D2 did not disclose a plurality of sensors, claim 15 would not be considered as involving an inventive step in the meaning of Article 33(3) PCT by just limiting the possible number of sensors to the system.

V-8 Furthermore, D2 discloses the subject-matter of claim 16 as any line can be seen as a slick line. Claim 16 is therefore not new (Article 33(2) PCT). See also section VIII-3.

V-9 Furthermore, D2 discloses the subject-matter of the following claims:

Claim 17: see fig. 1, item 56

Claim 18: see fig. 1, item 17

Claim 19: see col. 3, l. 48-52

Claim 20: see col. 2, l. 47

The subject-matter of said claims is therefore not new (Article 33(2) PCT).

V-10 Also the subject-matter of independent claim 21 and 22 is disclosed by D2. See in particular fig. 1 of D2. Refer also to sections V-5 above.

The subject-matter of claims 21 and 22 is therefore not new contrary to the provisions of Article 33(2) PCT.

V-11 Furthermore, D2 discloses the subject-matter of the following claims:

Claim 23: see fig. 1, item 17, where the cable 17 can be said to act as an antenna, i.e. the medium upon which the signal is transferred to the recorder 56.

Claim 24: see fig. 1, the socket is part of the arrangement referred to as 21.

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EXAMINATION REPORT - SEPARATE SHEET

Claim 25: as the signal is clearly going from the sensor 50 to cable 17, the socket must include means to expedite the signal through the socket.

The subject-matter of said claims is therefore not new (Article 33(2) PCT).

V-12 Claim 26 does not involve an inventive step (Article 33(3) PCT). See D3, fig. 3, item 30.

V-13 Independent method claim 27 relates effectively to the same subject-matter as independent claim 21 and does therefore also not meet the requirements of Article 33(2) PCT.

V-14 As far as claim 28 can be understood, said claim relates effectively to the same subject-matter as independent claim 21 and does therefore also not meet the requirements of Article 33(2) PCT. See also section VIII-2.

V-15 What has been said about claim 23 applies also to claim 29. The subject-matter of said claims is therefore not new (Article 33(2) PCT).

V-16 Furthermore, at least D2 discloses the subject-matter of the following claims:

Claim 30: see col. 4, l. 48-52

Claim 31: see col 5, l. 30-32

Claim 32: see fig. 1, item 56

Claim 34: see col 4, l. 40-52

Claim 35: see: col. 2, l. 47

The subject-matter of said claims is therefore not new (Article 33(2) PCT).

V-17 With respect to claim 33, it is considered as normal practice, in the industry, to select between the features of having one-way or two-way communication between two stations, when designing a telemetry link. said claim does therefore not involve an inventive step (Article 33(3) PCT).

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EXAMINATION REPORT - SEPARATE SHEET**Re Item VII****Certain defects in the international application**

- VII-1 The independent claims are not in the two-part form in accordance with Rule 6.3(b) PCT, which in the present case would be appropriate, with those features known in combination from D1-D2 being placed, where appropriate, in the preamble (Rule 6.3(b)(i) PCT) and with the remaining features being included in the characterising part (Rule 6.3(b)(ii) PCT).
- VII-2 The features of the claims are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT).
- VII-3 Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in D1-D4 is not mentioned in the description, nor are these documents identified therein.

Re Item VIII**Certain observations on the international application**

- VIII-1 To satisfy the conciseness requirement of Article 6 PCT, the present set of claims should include only the minimum necessary number of independent claims in any one category. Said requirement is not satisfied by any of the independent claims, as in the present case, it is considered appropriate to use only one independent claim in any one category.
- VIII-2 Claim 28 is not clear (Article 6 PCT) in that it can not be determined if the "configuration of the downhole tool or tool string", as specified in the claim, refers to the location of the tool in the borehole or if it refers to the composition of the casing as such, alternatively to the tool string being run inside the casing.
- VIII-3 At least claims 2, 13 and 16 do not meet the requirements of Article 6 PCT in that the matter for which protection is sought is not clearly defined as the term "slickline" does not univocally imply any specific structural feature. The claim attempts therefore to define the subject-matter in terms of the result to

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be achieved which merely amounts to a statement of the underlying
problem. The technical features necessary for achieving this result should be
added.

10/088124

Rec'd PCT/PTO

14 MAR 2002

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CLAIMS:-

1. A communication system for use in a wellbore, the system comprising a downhole tool, the downhole tool comprising a transmitter, the downhole tool being coupled to a wireline, wherein the downhole tool and wireline are adapted to be inserted into the wellbore, and a receiver located remotely from the transmitter, wherein the wireline is capable of running the downhole tool into the wellbore and is also capable of acting as an antenna for the transmitter.
2. An apparatus according to claim 1, wherein the wireline is a slickline.
3. An apparatus according to either of claims 1 or 2, wherein the transmitter is further associated with, provided on, or an integral part of a tool string.
4. An apparatus according to claim 3, wherein the downhole tool or tool string is suspended by the wireline.
5. An apparatus according to either of claims 3 or 4, wherein the transmitter transmits data collected or generated by the downhole tool or the like to the receiver.

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- 1 6. An apparatus according to any preceding claim,
2 wherein the receiver is located at, or near, the
3 surface of the wellbore.
4
- 5 7. An apparatus according to any preceding claim,
6 wherein the distance travelled by the downhole tool,
7 the status of the downhole tool or other parameters
8 of the downhole tool, can be transmitted to the
9 receiver.
10
- 11 8. Apparatus according to any preceding claim,
12 wherein the wireline is electrically insulated.
13
- 14 9. Apparatus according to any preceding claim,
15 wherein the wireline is sheathed to facilitate
16 electrical insulation.
17
- 18 10. A method of communication in a wellbore,
19 comprising providing a downhole tool comprising a
20 transmitter, coupling the downhole tool to a
21 wireline, paying an end of the wireline and the
22 downhole tool into the wellbore, and providing a
23 receiver located remotely from the transmitter, such
24 that the wireline acts as an antenna for the
25 transmitter.
26
- 27 11. A slickline for use in a wellbore, wherein the
28 slickline is provided with an insulating coating.
29
- 30 12. A slickline according to claim 11, wherein the
31 insulating coating is an outer coating of the
32 slickline.

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EMPFANGS/FII 11 OKI 16:58

AUSDRUCKS/FII 11 OKI 17:03

ART 34 AND 1

13. A slickline according to either of claims 11 or 12, wherein the coating comprises a stress/impact sensitive material.

14. A slickline according to any of claims 11 to 13, wherein the insulating coating comprises at least one enamel material.

15. A distance measurement apparatus for measuring the distance travelled by a wireline, the apparatus comprising at least two sensors coupled to the wireline wherein the sensors are capable of sensing known locations in a wellbore.

16. Apparatus according to claim 15, wherein the wireline is a slickline.

17. Apparatus according to either of claims 15 or 16, wherein the apparatus includes transmission means for transmitting data collected by the at least two sensors to a receiver located remotely from the apparatus.

18. Apparatus according to claim 17, wherein the wireline is capable of acting as an antenna for the transmission means.

19. Apparatus according to either of claims 17 or 18, wherein the sensors are coupled at or near a downhole tool whereby the distance travelled by the

AMENDED SHEET

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AUSDKUCKSZETT 11.03.1. 17:03

ART 34 AMDT

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1 tool, and the location of the tool within the
2 wellbore, can be calculated.

3
4 20. Apparatus according to any of claims 17 to 19,
5 wherein the wireline is electrically insulated.

6
7 21. A method of measuring the distance travelled by
8 a wireline, the method comprising the steps of
9 coupling at least two sensors to the wireline, the
10 at least two sensors being capable of sensing known
11 locations in a wellbore; running the wireline into
12 the wellbore; calculating the depth of the at least
13 two sensors; generating a signal when each of the at
14 least two sensors pass said known locations; using
15 the signals to calculate a depth correction factor;
16 and correcting the calculated depth using the depth
17 correction factor.

18
19 22. A downhole tool comprising coupling means to
20 allow the tool to be attached to a wireline, at
21 least two sensors capable of detecting known
22 locations in a wellbore and generating a signal
23 indicative thereof, and a transmission means capable
24 of transmitting the signals.

25
26 23. A downhole tool according to claim 22, wherein
27 the wireline acts as an antenna for the transmission
28 means.

29
30 24. A downhole tool according to either of claims
31 22 or 23, wherein the coupling means comprises a
32 rope-socket.

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1
2 25. A downhole tool according to claim 24, wherein
3 the rope-socket is provided with signal coupling
4 means to couple the signals generated by the
5 transmission means to the wireline.
6

7 26. A downhole tool according to any of claims 20
8 to 23, wherein the downhole tool is powered by a DC
9 power supply.
10

11 27. A method of tracking a member in a wellbore,
12 the method comprising providing at least two sensors
13 on the member, inserting the member and said sensors
14 into the wellbore, obtaining information indicating
15 the position of the sensors in the wellbore, and
16 determining the distance travelled by said member
17 from said sensor information.
18

19 28. Apparatus for indicating the configuration of a
20 downhole tool or tool string, the apparatus
21 comprising at least two sensors capable of sensing a
22 change in the configuration of the downhole tool or
23 tool string and generating a signal indicative
24 thereof, and a transmission means electrically
25 coupled to the at least two sensors for transmitting
26 the signals to a receiver.
27

28 29. Apparatus according to claim 28, wherein the
29 downhole tool is preferably suspended in a borehole
30 using a wireline, and the wireline is capable of
31 acting as an antenna for the transmission means.
32

AMENDED SHEET

EMPEANAC7EIT 11 OKT 16.58

AHSNRHCKC7EIT 11 OKT 17.03

43

1 30. Apparatus according to either of claims 28 or
2 29, wherein the transmitter facilitates the
3 transmission of data collected by the sensors to the
4 receiver.

5
6 31. Apparatus according to any of claims 28 to 30,
7 wherein the transmission means comprises a
8 transmitter.

9
10 32. Apparatus according to any of claims 28 to 31,
11 wherein the receiver is located at, or near, the
12 surface of the borehole.

13
14 33. Apparatus according to any of claims 26 to 30,
15 wherein the apparatus is arranged whereby it can
16 facilitate two-way communication between the
17 downhole tool and the receiver.

18
19 34. Apparatus according to any of claims 28 to 32,
20 wherein the sensors comprise electric or magnetic
21 sensors which are coupled to the downhole tool
22 wherein a discontinuity of the respective electric
23 or magnetic connection triggers a signal by each
24 sensor.

25
26 35. Apparatus according to any of claims 29 to 34,
27 wherein the wireline is electrically insulated.

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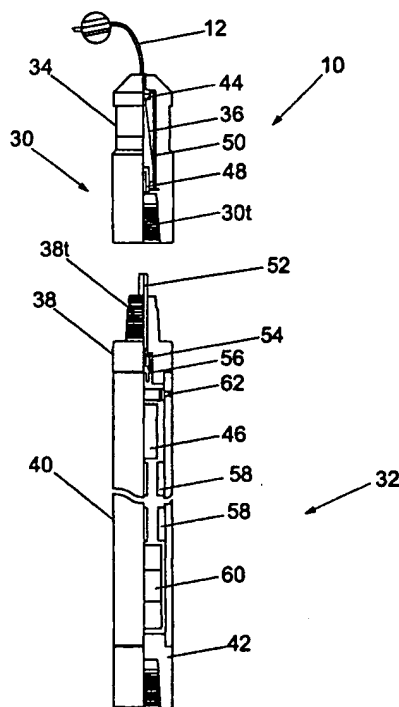
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[Continued on next page]

(54) Title: **APPARATUS AND METHODS RELATING TO DOWNHOLE OPERATIONS**



(57) Abstract: A communication system for use in a wellbore, a downhole tool, and a method includes a transmitter coupled to a wireline, and a receiver located remotely from the transmitter. The wireline is capable of acting as an antenna for the transmitter. The wireline is a slickline, and the transmitter may be associated with, provided on, or an integral part of a downhole tool or tool string. The transmitter typically transmits data collected or generated by the downhole tool or the like to the receiver, which is preferably located at, or near, the surface of the wellbore. The wireline is typically provided with an insulating coating. Also, a distance measurement apparatus and a method for measuring the distance travelled by a wireline includes at least one sensor coupled to the wireline, and the sensor is capable of sensing known locations in a wellbore.

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5/pals

1 **"Apparatus and Methods Relating to Downhole**
2 **Operations"**

3

4 The present invention relates to apparatus and
5 methods relating to downhole operations, and
6 particularly, but not exclusively, to wireline
7 operations.

8

9 Wireline is a term commonly used for the operation of
10 deploying and/or retrieving tools or the like using a
11 wire, the wire being one of several different types
12 of construction. For example, slicklines are wires
13 which comprise a single strand steel or alloy piano-
14 type wire which currently have a diameter of around
15 0.092 inches to 0.125 inches (approximately 2.34mm to
16 3.17mm) in use, with the possibility of increasing
17 this to 0.25 inches (approximately 6.25mm) in the
18 future.
19

1 Wirelines may also be of a braided construction which
2 can also carry single or multiple electrical
3 conductor wires through its core and is typically of
4 a diameter in the order of 3/16 of an inch
5 (approximately 4.76mm) or above. Slick tubing, more
6 commonly known as coiled tubing, is in the form of a
7 continuous hollow-cored steel or alloy tubing which
8 is usually of a diameter greater than the preceding
9 types of wireline.

10

11 Wirelines are conventionally used to insert and/or
12 retrieve downhole tools from a wellbore or the like.
13 The downhole tools are typically deployed to perform
14 various downhole functions and operations such as the
15 deployment and setting of plugs in order to isolate a
16 section of the wellbore. It is advantageous and
17 often essential to know the distance of travel of the
18 wireline so that the location of the tool within the
19 wellbore is known.

20

21 Wirelines are conventionally stored on a winching
22 unit typically located at the surface in the
23 proximity of the top of a borehole. It should be
24 noted that "surface" in this context is to be
25 understood as being either atmospheric above ground
26 or sea level, or aquatic above the seabed. Although
27 the methods and apparatus employed in wireline
28 operations vary in detail, the wireline is commonly
29 introduced into the wellbore (the wellbore
30 conventionally being cased, as is known) via a series
31 of sheaves or guide rollers. The sheaves or guide

1 rollers facilitate, in the first instance, a
2 substantially vertical orientation of the wireline.
3 The wireline passes through a substantially
4 vertically-orientated superstructure tube having an
5 internal open-ended bore, the tube being positioned
6 on top of a wellhead. Thus, any downhole tool can be
7 introduced into the wellbore.

8
9 The wireline is coupled at its distal (downhole) end
10 to the downhole tool, typically via a part of the
11 tool known as a rope-socket. The rope-socket is
12 conventionally used to provide a mechanical
13 connection between the wireline and the downhole tool
14 (or a string of downhole tools known as a tool
15 string).

16
17 The conventional method of measuring the downhole
18 tool depth is to run the wireline against a measuring
19 wheel which is a pulley wheel of known diameter. It
20 should be noted that use of "depth" in this context
21 is to be understood as being the trajectory length of
22 the downhole tool, which may be different from
23 conventional depth if the wellbore is deviated, for
24 example. In order to calculate the distance of
25 travel of the wireline, a number of variable factors
26 must be known. It is a prerequisite that the
27 rotational direction of the pulley wheel, the number
28 of revolutions thereof, the diameter of the pulley
29 wheel and, depending upon the type of pulley wheel
30 (that is, whether a point-type contact or arc for
31 example), the diameter of the wireline, must all be

1 known before the distance of travel of the wireline
2 within the wellbore can be calculated.

3

4 However, with this conventional method for
5 calculating the distance of travel of the wireline, a
6 number of factors can render the calculation
7 inaccurate. The occurrence of wheel slippage, the
8 stretch of the wireline (due to the weight of the
9 wireline itself, and/or the weight of the tool string
10 which is attached thereto), the effect of friction
11 and the well-contained fluid buoyancy all contribute
12 to decrease the accuracy of the tool depth
13 measurement.

14

15 In order to improve the accuracy of this conventional
16 depth measurement, it is known to combine the
17 measured tensile load, the known stretch co-efficient
18 of the wireline, and the conventionally measured tool
19 depth as described above, to recalculate the tool
20 depth measurement on a continuous basis (ie in real
21 time) using a processing means, such as a computer or
22 the like.

23

24 However, the accuracy of the aforementioned depth
25 measurement correction method relies on an
26 experimentally determined constant (ie the stretch
27 co-efficient of the wireline) and the surface
28 measurements on the wireline. The resulting
29 correction does not include the significant combined
30 effect that well fluid temperature, tool buoyancy and

1 well geometry have on the accuracy of the depth
2 correction.

3

4 According to a first aspect of the present invention
5 there is provided distance measurement apparatus for
6 measuring the distance travelled by a wireline, the
7 apparatus comprising at least one sensor coupled to
8 the wireline wherein the sensor is capable of sensing
9 known locations in a wellbore.

10

11 The wireline is typically a slickline.

12

13 According to a second aspect of the present invention
14 there is provided a method of measuring the distance
15 travelled by a wireline, the method comprising the
16 steps of coupling at least one sensor to the
17 wireline, the at least one sensor being capable of
18 sensing known locations in a wellbore; running the
19 wireline into the wellbore; calculating the depth of
20 the at least one sensor using any conventional means;
21 generating a signal when the at least one sensor
22 passes said known locations; using the signal to
23 calculate a depth correction factor; and correcting
24 the calculated depth using the depth correction
25 factor.

26

27 Preferably, the apparatus includes transmission means
28 for transmitting data collected by the at least one
29 sensor to a receiver located remotely from the
30 apparatus. Preferably, the wireline is capable of
31 acting as an antenna for the transmission means.

1

2 The sensor may be coupled to the wireline at any
3 point thereon, or may form an integral part thereof.

4 The sensor is preferably coupled at or near a
5 downhole tool whereby the distance travelled by the
6 tool (and thus its location within the wellbore) can
7 be calculated. Alternatively, the sensor may form
8 part of a downhole tool or the like.

9

10 The sensor typically comprises a magnetic field
11 sensor, and preferably an array of magnetic field
12 sensors. The array of magnetic field sensors are
13 typically provided on a common horizontal plane.
14 Alternatively, the sensor may comprise a radio
15 frequency (RF) sensor, and preferably an array
16 thereof. Where an RF sensor is used, the wellbore is
17 typically provided with RF tags at known locations.

18

19 The wireline is preferably electrically insulated.
20 The wireline may be sheathed to facilitate electrical
21 insulation. Alternatively, the wireline may be
22 passed through a stuffing box or the like to
23 facilitate electrical insulation and/or isolation.

24

25 According to a third aspect of the present invention
26 there is provided a downhole tool comprising coupling
27 means to allow the tool to be attached to a wireline,
28 at least one sensor capable of detecting known
29 locations in a wellbore and generating a signal
30 indicative thereof, and a transmission means capable
31 of transmitting the signal.

1

2 There is also provided a method of tracking a member
3 in a wellbore, the method comprising providing a
4 sensor on the member, inserting the member and sensor
5 into the wellbore, obtaining information indicating
6 the position of the sensor in the wellbore, and
7 determining the distance travelled by said member
8 from said sensor information.

9

10 The wireline is preferably used as an antenna for the
11 transmission means.

12

13 The coupling means typically comprises a rope-socket.
14 The rope-socket is preferably provided with signal
15 coupling means to couple the signal generated by the
16 transmission means to the wireline.

17

18 The sensor typically comprises a magnetic field
19 sensor, and preferably an array of magnetic field
20 sensors. The array of magnetic field sensors are
21 typically provided on a common horizontal plane.
22 Alternatively, the sensor may comprise a radio
23 frequency (RF) sensor, and preferably an array
24 thereof. The array of RF sensors are typically
25 provided on a common horizontal plane.

26

27 The downhole tool is preferably powered by a DC power
28 supply, and most preferably a local DC power supply.
29 The DC power supply typically comprises at least one
30 battery.

31

1 According to a fourth aspect of the present invention
2 there is provided a wireline wherein the wireline is
3 provided with an insulating coating.

4

5 The insulating coating is typically an outer coating
6 of the wireline. The wireline typically comprises a
7 slickline.

8

9 The insulating coating typically comprises at least
10 one enamel material. The enamel material typically
11 consists of one or more layers of coating whereby
12 each individual layer adds to the overall required
13 coating properties. Additionally, each layer of
14 enamel material preferably has the required bonding,
15 flexibility and stretch characteristics at least
16 equal to those of the wireline.

17

18 The enamel material can typically be applied to the
19 wireline by firstly applying a thin layer of
20 adhesive, such as nylon or other suitable primer.
21 Thereafter, one or more layers of an enamel material
22 such as polyester, polyamide, polyamide-imide,
23 polycarbonates, polysulfones, polyester imides,
24 polyether, ether ketone, polyurethane, nylon, epoxy,
25 equilibrating resin, or alkyd resin or theic
26 polyester, or a combination thereof, are preferably
27 applied. The enamel material is preferably
28 polyamide-imide.

29

30 According to a fifth aspect of the present invention
31 there is provided a communication system for use in a

1 wellbore, the system comprising a transmitter coupled
2 to a wireline, and a receiver located remotely from
3 the transmitter, wherein the wireline is capable of
4 acting as an antenna for the transmitter.

5

6 The wireline is typically a slickline.

7

8 The transmitter is typically associated with,
9 provided on, or an integral part of a downhole tool
10 or tool string, whereby the downhole tool or tool
11 string is typically suspended by the wireline.

12

13 The transmitter typically facilitates the
14 transmission of data collected by the downhole tool
15 or the like to the receiver. The transmission means
16 typically comprises a transmitter. The receiver is
17 typically located at, or near, the surface.

18

19 Optionally, the communication system is arranged
20 whereby it can facilitate two-way communication
21 between the downhole tool and the receiver. In this
22 embodiment, a transmitter and a receiver are
23 typically located downhole. Additionally, a
24 transmitter and a receiver are also located at, or
25 near, the surface. The transmitter and receiver at
26 the surface and/or downhole may be replaced by a
27 transceiver located downhole and at, or near, the
28 surface.

29

30 The transmitter may be coupled to the wireline at any
31 point thereon, or may form a part thereof. The

1 transmitter is typically coupled at or near a
2 downhole tool whereby the distance travelled by the
3 tool, the status of the tool or other parameters of
4 the tool, can be transmitted to the receiver.
5 Alternatively, the transmitter may form an integral
6 part of a downhole tool.

8 The wireline is preferably electrically insulated.
9 The wireline may be sheathed to facilitate electrical
10 insulation. Alternatively, the wireline may be
11 passed through a stuffing box or the like to
12 facilitate electrical insulation and/or isolation.

14 According to a sixth aspect of the present invention
15 there is provided apparatus for indicating the
16 configuration of a downhole tool or tool string, the
17 apparatus comprising at least one sensor capable of
18 sensing a change in the configuration of the downhole
19 tool or tool string and generating a signal
20 indicative thereof, and a transmission means
21 electrically coupled to the at least one sensor for
22 transmitting the signal to a receiver.

24 The downhole tool is preferably suspended in a
25 borehole using a wireline, and the wireline is
26 preferably capable of acting as an antenna for the
27 transmission means.

29 The transmitter typically facilitates the
30 transmission of data collected by the sensor to the
31 receiver. The transmission means typically comprises

1 a transmitter. The receiver is typically located at,
2 or near, the surface.

3

4 Optionally, the communication system is arranged
5 whereby it can facilitate two-way communication
6 between the downhole tool and the receiver. In this
7 embodiment, a transmitter and a receiver are
8 typically located downhole. Additionally, a
9 transmitter and a receiver are also located at, or
10 near, the surface. The transmitter and receiver at
11 the surface and/or downhole may be replaced by a
12 transceiver located downhole and at, or near, the
13 surface.

14

15 The sensor typically comprises an electric or
16 magnetic sensor which is coupled to the downhole tool
17 wherein a discontinuity of the electric or magnetic
18 connection triggers a signal, or a plurality of
19 signals. These signals can then be transmitted to
20 the surface to indicate the status of the tool. In
21 one embodiment, the sensor may be coupled between a
22 tool string and a downhole tool which is to be
23 deployed into a wellbore, wherein discontinuity of
24 the electric or magnetic connection indicates that
25 the tool has been deployed. Alternatively, the
26 sensor may be coupled to a distal end of the tool
27 string, and the downhole tool which is to be
28 retrieved from a wellbore, is provided with a similar
29 sensor, wherein continuity of the electric or
30 magnetic connection indicates that the tool has been
31 retrieved.

1

2 The sensor may also be coupled to part of a downhole
3 tool which changes status during operation of the
4 tool (ie a valve, sleeve or the like) wherein the
5 sensor indicates the status of the part of the
6 downhole tool by a change in continuity.

7

8 The sensor may comprise a proximity sensor, magnetic
9 sensor or the like.

10

11 The wireline is preferably electrically insulated.
12 The wireline may be sheathed to facilitate electrical
13 insulation. Alternatively, the wireline may be
14 passed through a stuffing box or the like to
15 facilitate electrical insulation and/or isolation.

16

17 Embodiments of the present invention shall now be
18 described, by way of example only, with reference to
19 the accompanying drawings in which:

20 Fig. 1 is a part cross-section of a downhole
21 tool according to a third aspect of the present
22 invention;

23 Fig. 2 is a schematic diagram of a typical
24 wireline apparatus;

25 Fig. 3 is an enlarged view of part of the
26 wireline apparatus of Fig. 2;

27 Fig. 4 is a schematic diagram of a transmitter
28 which forms part of an electronic system for use
29 with the downhole tool of Fig. 1; and

30 Fig. 5 is a schematic diagram of a receiver
31 which forms part of an electronic system located

1 which guides the slickline 12 from a substantially
2 upward direction through 180° to a substantially
3 downward direction. The slickline 12 then passes
4 through a stuffing box, generally designated 24 in
5 Fig. 3, which typically includes an internal blow-out
6 preventer (BOP) 26.

7
8 The slickline 12 enters the tube 18 and continues
9 downward therethrough and into a main BOP 28 and the
10 wellhead 20.

11
12 The slickline 12 is coupled at a lower end thereof to
13 a part of a downhole tool commonly known as a rope-
14 socket 30 (Fig. 1). The main function of a rope-
15 socket 30 is to provide a mechanical linkage between
16 the slickline 12 and the tool or tool string. The
17 mechanical linkage may be any one of a plurality of
18 different forms, but is typically a self-tightening
19 means. In the embodiment shown in Fig. 1, the rope-
20 socket 30 includes a wedge or wire retaining cone 34
21 which engages in a correspondingly tapered retaining
22 sleeve 36.

23
24 The rope-socket 30 is also provided with a sealing
25 means which seals around the slickline 12 to provide
26 a seal between the rope-socket 30 and the well
27 environment around the slickline 12. The sealing
28 means typically comprises a seal or gasket 44 which
29 isolates and insulates the interior of the rope-
30 socket 30 from the well environment.

31

1 In the embodiment shown in Fig. 1, the rope-socket 30
2 also provides an electrical coupling between the
3 slickline 12 which is capable of acting as a
4 transmitter/receiver radio frequency (RF) antenna and
5 a downhole tool 32. The tool 32 typically comprises
6 an upper sub 38 which is coupled (typically by
7 threaded connection) to an intermediate sub 40, which
8 is in turn coupled (typically by threaded connection)
9 to a lower sub 42.

10

11 The upper sub 38 is provided with a screw thread 38t,
12 typically in the form of a pin, which engages with a
13 corresponding internal screw thread 30t, typically in
14 the form of a box, on the rope-socket 30. These
15 (threaded) connections 30t, 38t allow the rope-socket
16 30 and tool 32 to be (mechanically) coupled together.

17

18 Additionally, the rope-socket 30 is provided with
19 coupling means which electrically couples a metal or
20 otherwise electrically conductive portion of the
21 slickline 12 and a transmitter 46 (a transceiver
22 typically being used to facilitate two-way
23 communication) of the tool 32. The coupling means
24 typically comprises an electrical terminal 48 which
25 is electrically isolated from the body of the rope-
26 socket 30 using an insulating sleeve 50.

27

28 The upper sub 38 of the tool 32 is provided with an
29 electrical pin or contact plunger 52 which engages
30 with the electrical terminal 48 within the rope-
31 socket 30. The contact plunger 52 is typically

1 spring-loaded using spring 54 so that it can move
2 longitudinally (with respect to a longitudinal axis
3 of the tool 32) to facilitate coupling of the rope-
4 socket 30 and the tool 32. A lower end of the
5 plunger 52 is in contact with a main contactor 56
6 which is electrically coupled to the transmitter 46.
7 This facilitates coupling of signals generated by the
8 transmitter 46 through the plunger 52 and the
9 terminal 48 to the slickline 12, the slickline 12
10 acting as an antenna for transmitting and/or
11 receiving signals, as will be described.

12

13 The tool 32 is also provided with an array of field
14 sensors 58 which are used to detect differences in
15 the magnetic flux at the junctions of, or collars
16 between, successive casing sections which are used to
17 case the wellbore, whereby the location of the tool
18 32 within the wellbore can be calculated, as will be
19 described.

20

21 The tool 32 is preferably powered by a (local) direct
22 current (DC) power source, typically comprising one
23 or more batteries 60. The batteries 60 provide a
24 local electrical power supply for the tool 32.

25 Conventionally, downhole tools are powered using a
26 central conductor of a braided line to transmit
27 electrical power to the tool from the surface.

28 However, there are substantial losses using this
29 method, particularly where the tool is located some
30 distance down the wellbore. In addition, the central
31 conductor of the braided line is typically relatively

1 small in diameter and thus high voltage drops can be
2 induced. Use of a local power supply (ie the
3 batteries 60) obviates the need for an electrical
4 power connection to the surface.

5

6 The tool 32 may include a pressure sensor 62 which is
7 electrically coupled to the transmitter 46 and when
8 present can be used to measure the pressure external
9 to the tool 32.

10

11 Referring now to Fig. 4, there is shown a schematic
12 diagram of a transmitter 46 which forms a part of an
13 electronic system located within the tool 32. The
14 batteries 60 provide electrical power to the system
15 in general. On detection of a positive over-pressure
16 to atmospheric level, that is after introducing the
17 tool 32 into the tube 18 (Fig. 2) and opening of the
18 wellhead 20 to allow well pressure to equalise in the
19 tube 18, the pressure sensor 62 activates the
20 magnetic field sensors 58.

21

22 The magnetic field sensors 58 may be of the type
23 described in German Patent Application Number DE-A1-
24 19711781.3 (Pepperl + Fuchs GmbH), for example, and
25 are typically mounted within a section of the tool 32
26 which is at least partially manufactured from a
27 conventional non-ferrous material. This ensures high
28 sensitivity when detecting casing or collar joints.

29

30 German Patent Application Number DE-A1-19711781.3
31 describes use of the sensors 58 in conjunction with a

1 remnance inducing magnet ring. The wellbore casing
2 sections described therein exhibit a weak magnetic
3 remnance due to the influence of the earth's magnetic
4 field, the difference in the magnetic flux and/or the
5 history of previous well service operations. If the
6 difference in the magnetic flux at the junctions
7 between the wellbore casing sections is
8 insufficiently weak or disorientated, it is
9 advantageous to re-magnetise the casing sections by
10 either running in a separate downhole tool provided
11 with one or more axially orientated magnets prior to
12 commencing the tool detection, or to incorporate one
13 or more such magnets into the tool 32, or the tool
14 string of which the tool 32 forms part.

16 The plurality of sensors 58 are orientated to
17 preferentially sense the locality and proximity of a
18 collar or casing joint which the tool 32 passes, by
19 detecting the variation or switch in magnetic flux at
20 the junctions or collars between successive casing
21 sections. It is preferred, but not essential, to
22 have the sensors 58 disposed on a common horizontal
23 plane within the tool 32. The latter, in combination
24 with the series connection of the sensors 58 maximise
25 the positive sensing of the collars or casing joints
26 as the tool 32 passes.

28 When a casing collar or joint is detected, power is
29 supplied to the transmitter 46. The transmitter 46
30 is located within the tool 32 and is electrically
31 coupled to the batteries 60, the pressure sensor 62

1 and the magnetic field sensors 58 via suitable
2 electrical connections within the tool 32.
3 Alternatively, the transmitter 46 may be coupled
4 thereto via a system of insulated downhole tool
5 components which provide electrical connections
6 isolated from the well environment, the electrical
7 connections being suitable connectors between the
8 separate downhole sections which make up the complete
9 downhole tool string.

10

11 The transmitter 46 may be of a type supplied by RS
12 Components under catalogue number RS 740-449, which
13 is designed to operate in conjunction with a 418 MHz
14 FM transmitter module also supplied by RS Components
15 under catalogue number RS 740-297. However, it
16 should be noted that the transmitter specified above
17 is only an example of one possible transmitter, and
18 that there are many other possible transmitters and
19 frequencies which could be utilised in it's place.
20 The components identified above should be tested for
21 conformity to the particular operational requirements
22 and criteria and for operation in wellbore
23 environments.

24

25 The transmitter 46 typically has the facility for
26 address coding (using DIL switch settings 66 in Fig.
27 4), and data bit settings using either a DIL switch
28 68 (Fig. 4) or driven by external switches, relay
29 transistors or CMOS logic via an auxiliary connector,
30 designated 70 in Fig. 4). DIL switch 68 is used to
31 switch data channels (ie the four data channels

1 relating to each one of the sensors 58) on and off,
2 typically using opto-electronic switches 69. Thus,
3 the signal from any one, some or all of the sensors
4 58 can be set to be transmitted. The output from the
5 DIL switch 66 is typically processed by an encoder
6 convertor 67 which encodes the address coding (as set
7 by the DIL switch 66) into the transmission. RF
8 transmission can be initiated by external contact
9 closure and the provided link on the auxiliary
10 connector 70 (eg, coupling TXEN to ground).

11

12 It will be appreciated that with the above described
13 transmission method, the transmitter 46 is not
14 permanently activated and allows only a single
15 transmission upon external contact closure. The
16 duration of the transmission may be altered by
17 changing the values of RT, CT and/or RT2 and CT2
18 respectively, but is typically in the order of 1
19 second duration (set by default). The period of
20 transmission may be determined as follows :-

21 $2.2 \cdot RT \cdot CT$ (which changes the interval between
22 transmission in seconds) and $0.7 \cdot RT2 \cdot CT2$ (which
23 changes the duration of the transmissions in
24 seconds).

25

26 The transmitter 46 ground connection (ie from any
27 point on the ground connection 64) and RFout
28 connection 65 are electrically coupled to the rope-
29 socket 30 using, for example, electrical connections
30 within the tool 32 (or otherwise as described above)
31 and the plunger 52 and electrical terminal 48

1 provided on the tool 32 and rope-socket 30
2 respectively (Fig. 1). These connections are shown
3 schematically in Fig. 4, with the RFout connection 65
4 being coupled to the slickline 12 which acts as an
5 antenna.

6
7 As previously noted, the slickline 12 acts as an
8 antenna for this RF transmission and thus the
9 slickline antenna 12 carries and guides the
10 transmission towards the surface. The RF
11 transmission (ie the electromagnetic (modulated)
12 wave) contains encoded data which is radiated into
13 free-space or any other antenna surrounding medium at
14 or near the tube 18, for example. The precise
15 location of where the RF transmission is radiated
16 into free-space is not important, but it is typically
17 at some point at the surface where the RF
18 transmission can be radiated over a larger area.

19
20 Located within the radiation range of the transmitter
21 antenna (ie the slickline 12), for example located at
22 the surface or within the tube 18, is a receiver 80,
23 shown in Fig. 5. Fig. 5 is a schematic diagram of
24 the receiver 80 which forms a part of an electronic
25 system located at or near the surface. The receiver
26 80 may be, for example, of the type supplied by RS
27 Components under catalogue number RS 740-455, which
28 is designed to operate in conjunction with a 418 MHz
29 FM receiver module 84 supplied by RS Components under
30 catalogue number RS 740-304. However, it should be
31 noted that the receiver specified above is only an

1 example of one possible receiver, and that there are
2 many other possible receivers which could be utilised
3 in it's place. It should also be noted that the
4 receiver 80 should be matched to the frequency of the
5 transmitter 46. The components identified above
6 should be tested for conformity to the particular
7 operational requirements and criteria and for
8 operation in wellbore environments.

9
10 The receiver 80 typically has the facility for
11 address coding (using suitable DIL switch settings on
12 switch 82) to match and pair with the address code of
13 the transmitter 46. The settings of the receiver
14 board jumpers JP1 and JP2 determine the output
15 configuration of the transmission from the tool 32.
16 Jumper JP2 is used to select whether the output is
17 high or low (ie the logic level) which selects
18 whether the output on the four channels out 0 to out
19 3 on an auxiliary connector 88) are either a logic
20 high or a logic low. Jumper JP1 is used to select
21 whether the output on the channels out 0 to out 3 are
22 latched (ie permanently high or low) or intermittent.

23
24 The receiver module 84 receives the signal from the
25 antenna 12 at an RFin connection 86. The signal is
26 then processed in the FM receiver module 84 and
27 output to a decoder 90. The decoder 90 decodes the
28 address coding from the transmission and thus the
29 receiver 80 is only activated when the address of the
30 transmitter 46 matches the address settings of the
31 DIL switch 82 (ie the address of the receiver 80).

1 The output from the decoder 90 is then fed to a data
2 selector 92 which automatically activates one, some
3 or all of the output channels out 0 to out 3,
4 depending upon which of the four channels have been
5 activated by the settings of the DIL switch 68 on the
6 transmitter 46. The output of the selector 92 is
7 then fed to a seven stage darlington driver 94 which
8 is used to drive the outputs on the auxiliary
9 connector 88. The outputs of the auxiliary connector
10 88, in particular the outputs out 0 to out 3 are
11 typically coupled to a visual indicator (ie a light
12 emitting diode (LED)) which can be used to allow a
13 user to determine which of the sensors 58 detected a
14 collar or casing joint. Alternatively, or
15 additionally, the outputs of the auxiliary connector
16 88 may be coupled to a processing means (eg a
17 computer) located at or near the surface for further
18 processing of the data.

19
20 It should be noted that although the transmitter 46
21 is shown coupled to four sensors 58 (Fig. 4) and thus
22 has four channels, the transmitter 46 may be provided
23 with more or less than four channels, depending upon
24 the number and grouping of sensors 58 within tool 32.

25
26 In use, the tool 32 is attached to the slickline 12
27 as described above and introduced into a cased
28 wellbore in a conventional manner. The casing can be
29 of any type, that is, for example, either
30 electrically conductive or semi-conductive
31 ferromagnetic casing, or electrically non-conductive

1 or non-ferromagnetic casing. The casing string
2 typically comprises of a plurality of casing lengths
3 which are threadedly coupled together, thus making
4 joints (or collars) therebetween.

5
6 The tool 32 is lowered into the cased wellbore using
7 the slickline 12. The slickline 12 is typically
8 formed of a metal which has a high yield strength to
9 weight ratio and is capable of supporting the tool 32
10 (and any other tools which may form part of a
11 downhole tool string). It will be appreciated that
12 the slickline 12 should also be capable of
13 functioning as a monopole antenna.

14
15 The slickline 12 is preferably (but not essentially)
16 electrically insulated and/or isolated using a thin
17 outer coating of a flexible, non-conductive
18 insulating material. It is preferred that the
19 material should also be chemical, abrasion and
20 temperature resistant to endure the hazardous
21 downhole environments. The coating is typically an
22 enamel coating.

23
24 It should be noted that it may not be necessary to
25 provide an insulating coating on the slickline 12.
26 If a stuffing box or the like is used, the slickline
27 12 will be electrically isolated by the stuffing box.
28 However, this requires that the slickline 12 does not
29 come into contact with any part of the conductive
30 wellbore which may be difficult in deviated
31 (horizontal) wells or the like. It is thus preferred

1 that the slickline 12 is coated with an insulating
2 coating to ensure good electrical isolation. It
3 should be noted that coating the slickline 12 with an
4 enamel material also protects the metal wire (from
5 which the slickline 12 is made) against corrosion.
6 In addition, or alternatively, a corrosive chemical
7 sensitive material(s) may be applied as a coating or
8 part thereof on the slickline 12, and this would have
9 the advantage that the presence of corrosive
10 chemicals, such as H₂S or CO₂ or nitrates, in the
11 well would be indicated to the operator when the
12 slickline 12 is removed from the well since the
13 corrosive chemical sensitive material will be
14 transformed; for example, the colour of the corrosive
15 chemical sensitive material may change. In addition,
16 or alternatively, a stress/impact sensitive
17 material(s) may be applied as a coating or part
18 thereof on the slickline 12, and this would have the
19 advantage that mechanical damage to the slickline 12
20 in the well would be indicated to the operator when
21 the slickline 12 is removed from the well, since the
22 stress/impact sensitive material will be transferred;
23 for example, the colour of the impact/stress
24 sensitive material may change.

25

26 The enamel material may consist of one or more layers
27 of coating whereby each individual layer adds to the
28 overall required coating properties. Additionally,
29 each layer of enamel material preferably has the
30 required bonding, flexibility and stretch
31 characteristics at least equal to those of the metal

1 slickline 12 or coiled tubing. The thickness of the
2 enamel material can vary depending upon the downhole
3 conditions encountered, but is generally in the order
4 of 10 to 100 microns.

5
6 The enamel material can typically be applied to the
7 slickline 12 by firstly applying a thin layer of
8 adhesive, such as nylon or other suitable primer.
9 Thereafter, one or more layers of an enamel material
10 such as polyester, polyamide, polyamide-imide,
11 polycarbonates, polysulfones, polyester imides,
12 polyether, ether ketone, polyurethane, nylon, epoxy,
13 equilibrating resin, or alkyd resin or theic
14 polyester, or a combination thereof. The enamel
15 material is preferably polyamide-imide.

16
17 The conventional method of measuring downhole tool
18 depth is to run the slickline 12 against the sheave
19 wheel 22. It should be noted that use of "depth" in
20 this context is understood as being the trajectory
21 length of the downhole tool, which may be different
22 from conventional depth if the wellbore is deviated,
23 for example. In order to calculate the distance of
24 travel of the slickline 12, a number of variable
25 factors must be known. It is a prerequisite that the
26 rotational direction of the sheave wheel 22, the
27 number of revolutions thereof, the diameter of the
28 sheave wheel 22 and, depending upon the type of
29 sheave wheel 22 (that is, whether a point-type
30 contact or arc for example), the diameter of the
31 slickline 12, must all be known before the distance

1 of travel of the slickline 12 within the wellbore can
2 be calculated (and thus the depth of the tool).

3

4 However, with this conventional method for
5 calculating the distance of travel of the slickline
6 12, a number of factors render the calculation
7 inaccurate. The occurrence of wheel slippage, the
8 stretch of the slickline 12 (whether due to the
9 weight of the slickline 12 itself, or the weight of
10 the tool string to which it is attached), the effect
11 of friction and the well-contained fluid buoyancy all
12 contribute to decrease the accuracy of the
13 conventional tool depth measurement.

14

15 In order to improve the accuracy of this conventional
16 depth measurement, it is known to combine the
17 measured tensile load, the known stretch co-efficient
18 of the slickline 12, and the conventionally measured
19 tool depth as described above, to recalculate the
20 tool depth measurement on a continuous (ie real time)
21 basis using a processing means (eg a computer).

22

23 However, the accuracy of the aforementioned depth
24 measurement correction method relies on an
25 experimentally determined constant (ie the stretch
26 co-efficient of the slickline 12) and the surface
27 measurements of the weight of the slickline 12. The
28 resulting correction does not include the significant
29 combined effect that well fluid temperature, tool
30 buoyancy and well geometry have on the accuracy of
31 the depth correction.

1
2 When the tool 32 detects a casing collar or joint
3 during normal slickline operations at downhole tool
4 travelling speed, the tool 32 will process the
5 collected data at normal wireline operational speed
6 using a processing device and signal generator 71
7 (Fig. 4) which forms part of the transmitter 46. The
8 processing device and signal generator 71
9 communicates a signal (via a SAW oscillator 73 and
10 418 MHz band-pass filter 75) indicative of the
11 location of the collar or joint to the slickline 12
12 which acts as an antenna. At the surface, this
13 signal is received by the surface receiver 80 (Fig.
14 5). The receiver 80 is coupled to the processing
15 means (eg a computer) located at the surface and the
16 signal from the tool 32 is used to calibrate the
17 conventional measured depth against the known
18 distance between the preceding collar or joint, or
19 other known location. This distance is typically
20 known from an existing record log of the individual
21 casing lengths.

22
23 A number of arrays of magnetic field sensors 58
24 positioned on axially spaced-apart horizontal planes
25 within the tool 32 (as shown in Fig. 1) can be used,
26 each of the sensor arrays having their own channel as
27 described above and being set at known (but not
28 necessarily equal) distances along the longitudinal
29 axis of the tool 32. This allows for increased
30 accuracy of the calibration due to the repeated
31 calibration against the detected collar or joint. It

1 should be noted that when using multiple arrays of
2 sensors 58, only a single transmitter 46 and receiver
3 80 need be used as each array 58 will have their own
4 individual channel which can be selected or
5 deselected as required.

6
7 However, if the communication system is being used
8 with other sensors within the tool, these other
9 sensors may be coupled to another transmitter and
10 receiver, the other transmitter and receiver
11 including a different address coding. This allows
12 multiple transmissions to multiple receivers 80 from
13 multiple transmitters 46 using only one slickline 12
14 as the antenna.

15
16 The signal from the tool 32 is, for the purpose of
17 the described tool depth measurement calibration, a
18 measure of a known trajectory length of the tool 32
19 in relation to a detected collar or casing joint end
20 length (casing-section length calibration). This is
21 dependent upon the configuration of tool 32 within
22 the downhole tool or string. Alternatively, the
23 signal is a measure of the trajectory length as
24 travelled by the tool 32 in relation to the detected
25 collar or casing joint as indicated by each separate
26 positive signal from the tool 32 (downhole tool
27 length calibration). For the casing section length
28 calibration technique, the accuracy of the
29 calibration may depend upon the accuracy and
30 completeness of surveyed well details, that is the
31 length of the individual casing sections and the

1 configuration thereof. For the downhole tool length
2 calibration method, surveyed well details are not
3 necessary.

4
5 With the casing length calibration method
6 (hereinafter CLC), the trajectory length or tool
7 depth calibration, as performed by the processing
8 means at the surface, uses the received signal from
9 the tool 32 and references this signal against the
10 conventionally obtained surface measured depth,
11 obtained as described above, and the details of the
12 well. That is, the individual casing length is used
13 to calculate a depth correction factor μ wherein

$$\mu_{CLC} = L_c / (D_2 - D_1),$$

14
15
16
17 wherein

18
19 L_c = casing length;

20 D_1 = surface depth at the previous casing collar or
21 joint;

22 D_2 = surface depth at the detected casing collar or
23 joint, where $D_2 > D_1$; and

24 μ_{CLC} = depth correction factor.

25

26 The depth correction factor μ_{CLC} is used by the
27 processing means to correct the conventionally
28 obtained depth over the next downhole tool trajectory
29 casing length.

30

1 With the downhole tool length calibration method
 2 (hereinafter TLC), the trajectory length or tool
 3 depth calibration is performed by the processing
 4 means located at the surface, for example. The
 5 processing means uses the received signal from the
 6 tool 32 and references this signal against the
 7 conventionally obtained surface measured depth to
 8 calculate a depth correction factor μ . The
 9 correction factor μ can be calculated as follows for
 10 equidistant sensor spacing (ie constant distance
 11 between sensors)

12

$$\mu_{TLC} = L_u / (D_n - D_{n-1}),$$

14

15 wherein

16

17 L_u = tool sensor distance constant (ie the uniform
 18 distance between the sensors);

19 D_1 = surface depth at the first tool sensor;

20 D_{n-1} = surface depth at the previous casing collar or
 21 joint;

22 D_n = surface depth at the detected casing collar or
 23 joint, where $D_n > D_{n-1} > D_1$; and

24 μ_{TLC} = depth correction factor.

25

26 The correction factor μ can be calculated as follows
 27 for non-uniform sensor spacing (ie non-constant
 28 distance between sensors)

29

$$\mu_{TLC} = L_n / (D_n - D_{n-1}),$$

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wherein

L_n = tool sensor distance spacing (ie the non-uniform distant between the sensors);
 D_1 = surface depth at the first tool sensor;
 D_{n-1} = surface depth at the previous casing collar or joint;
 D_n = surface depth at the detected casing collar or joint, where $D_n > D_{n-1} > D_1$; and
 μ_{TLC} = depth correction factor.

The depth correction factor μ_{TLC} thus derived can be used by the processing means to correct the conventionally obtained depth over the next travelled spacing between the sensors (either uniform or non-uniform). If the total tool distance (that is the distance between the sensors provided in the tool 32) is less than the individual casing length, the derived multiple-calibrated correction factor μ_{TLC} may be used to correct the conventionally obtained depth related input over the next downhole tool trajectory individual casing length.

It will be appreciated that the depth correction described above need not be performed in real-time. A running history file can be constructed using each surface-received signal from the tool 32 and after completion of a slickline run (downhole tool travel from surface to a depth and return to surface), the history file can be compared against a similar file

1 derived from the conventional depth measurement
2 technique and the results analysed to interpret and
3 evaluate the downhole tool run objectives and
4 results.

6 It will be appreciated that the use of a slickline as
7 an antenna is not limited to facilitate an increase
8 in accuracy of tool depth measurements. For example,
9 the conventional method for detecting the status of a
10 downhole tool or tools (that is a tool which is
11 designed to perform downhole functions such as setting
12 plugs or isolating sections of the wellbore to deploy
13 memory gauges) would be by a differential calculation
14 involving the experience of the slickline operator in
15 conjunction with correlated depth between distance
16 travelled by the slickline (calculated using the
17 conventional technique) and the location of a
18 "nipple" in conjunction with the previously recorded
19 "nipple" depth or tubing tally, or by other means
20 involving physical stresses in the slickline (for
21 example increased/decreased tension in the
22 slickline). A "nipple" is a receptacle in which the
23 downhole tool locates and latches into, or the
24 position in the tubing or casing string for the
25 deployment of the downhole tool to carry out its
26 function.

28 Once the downhole tool has been deployed or
29 retrieved, the slickline winch operator typically
30 sees a corresponding decrease or increase in the
31 weight of the tool string equivalent to the weight of

1 the tool, which would be indicative of a successful
2 deployment or retrieval.

3

4 However, where the downhole tool is of a marginal
5 weight so as not to show a significant difference in
6 the weight of the tool string once it has been
7 deployed or retrieved, or when circumstances inside
8 the wellbore give a smaller indication than one of
9 those described above (for example an obstruction in
10 the tubing or such like), the status of the downhole
11 tool is derived by conjecture until a time when the
12 function of the tool can be operatively tested or the
13 tool string is returned to the surface.

14

15 As will be appreciated, these methods of ascertaining
16 the status of downhole tools are not accurate and
17 rely on the experience of the slickline winch
18 operator, a careful tally of running and pulling
19 weights, and accurate weight indication and depth
20 correlation means. Even when these criteria have all
21 been met, there is no guarantee that the downhole
22 tool has been successfully deployed or retrieved
23 correctly and where downhole tools which rely on the
24 position of sliding sleeves are used, there is no
25 indication of the position thereof until further
26 tests have been carried out.

27

28 The present invention facilitates a means to actively
29 identify when a downhole tool has been deployed or
30 retrieved etc by incorporating into the previously
31 described apparatus one or more sensors (eg a

1 proximity or electrically connecting/disconnecting
2 sensor) which activates the transmission of a signal
3 via the slickline antenna which is indicative of the
4 status of the tool (ie latched, unlatched, engaged,
5 disengaged etc). This would provide a more reliable
6 indication of the tool status in connection with the
7 previously described depth correlation which
8 substantially mitigates the possibility of human
9 error in identifying whether the downhole tool has
10 been correctly deployed or retrieved etc.

11
12 When a downhole tool has been deployed, retrieved or
13 otherwise, it is normally the case to use a
14 mechanical force in order to facilitate this
15 deployment, retrieval or otherwise in order to
16 operate a mechanism incorporated in the downhole tool
17 in order to carry out the function of the tool. An
18 example of this would be a running tool which is used
19 to deploy a downhole plug which typically relies on
20 the slickline operator to locate the tool in its
21 downhole position using the conventional depth
22 measurement. Thereafter, either pulling sharply on
23 the slickline or rapidly slackening it induces a
24 hammering effect on the tool whereby a pin (or a
25 plurality thereof) are sheared to allow the tool to
26 engage in a locking assembly, thus disconnecting the
27 tool from the string, or a collar is pulled to
28 retract such an assembly in order to release the tool
29 from the locking assembly thus connecting the tool to
30 the string.

31

1 A signal from a proximity sensor or the like can be
2 propagated to the surface using the slickline as an
3 antenna, the signal being received at the surface and
4 causing, for example, a second signal to be
5 transmitted from the surface to a relay provided on
6 the (downhole) tool to electrically or
7 electromechanically operate an automatic locking or
8 unlocking device. This would eliminate the
9 requirement for mechanical hammering to initiate the
10 functioning of the downhole tool.

11
12 Another application of the present invention would be
13 during the deployment of downhole tools, a part or
14 parts of the tool itself or the tool string can
15 loosen or be disconnected from the tool or string.
16 This can then require several runs into the wellbore
17 in order to recover the tool or part thereof. This
18 can be a very expensive process.

19
20 To overcome this, the tools within the tool string or
21 the parts of the tool themselves can be coupled
22 together either electrically or magnetically wherein
23 discontinuity of the electrical or magnetic
24 connection triggers a signal or a plurality of
25 signals which can be transmitted to the surface to
26 indicate to the slickline operator that such an event
27 is about to occur.

28
29 Modifications and improvements may be made to the
30 foregoing without departing from the scope of the
31 present invention. For example, the foregoing

1 description relates to the use of a slickline as an
2 antenna, but it will be appreciated that it is
3 equally possible to use a braided line or a mono-
4 conducting slickline. Additionally, the pulsed
5 transmission to the surface could be replaced by a
6 continuous type transmission, or alternatively, may
7 be a pulsed or continuous two-way communication
8 between the surface and a tool, using suitable
9 transmitters and receivers (or transceivers) for such
10 communications.

11
12 Although the foregoing description relates to the use
13 of a tool which detects the location and passage of
14 collars in a cased wellbore, it will be appreciated
15 that tools exist which are sensitive to non-collared
16 pipe joints.

17
18 Additionally, it will be appreciated that the
19 communication system described herein enables the use
20 of a slickline in combination with downhole tools,
21 such as flow meters, pressure, temperature,
22 gravitational, sonic and seismic sensors, downhole
23 cameras and/or optic/IR sensors which have hitherto
24 relied on electric (single- or multi-conductor)
25 braided slicklines for operation.

26

27

CLAIMS:-

1. A communication system for use in a wellbore, the system comprising a transmitter coupled to a wireline, and a receiver located remotely from the transmitter, wherein the wireline is capable of acting as an antenna for the transmitter.

2. An apparatus according to claim 1, wherein the wireline is a slickline.

3. An apparatus according to either of claims 1 or 2, wherein the transmitter is associated with, provided on, or an integral part of a downhole tool or tool string.

4. An apparatus according to claim 3, wherein the downhole tool or tool string is suspended by the wireline.

5. An apparatus according to either of claims 3 or 4, wherein the transmitter transmits data collected or generated by the downhole tool or the like to the receiver.

6. An apparatus according to any preceding claim, wherein the receiver is located at, or near, the surface of the wellbore.

7. An apparatus according to any preceding claim, wherein the transmitter is coupled to the wireline at

1 or near a downhole tool whereby the distance
2 travelled by the tool, the status of the tool or
3 other parameters of the tool, can be transmitted to
4 the receiver.

5

6 8. Apparatus according to any preceding claim,
7 wherein the wireline is electrically insulated.

8

9 9. Apparatus according to any preceding claim,
10 wherein the wireline is sheathed to facilitate
11 electrical insulation.

12

13 10. A method of communication in a wellbore,
14 comprising providing a transmitter coupled to a
15 wireline, paying an end of the wireline and the
16 transmitter into the wellbore, and providing a
17 receiver located remotely from the transmitter, such
18 that the wireline acts as an antenna for the
19 transmitter.

20

21 11. A wireline for use in a wellbore, wherein the
22 wireline is provided with an insulating coating.

23

24 12. A wireline according to claim 11, wherein the
25 insulating coating is an outer coating of the
26 wireline.

27

28 13. A wireline according to either of claims 11 or
29 12, wherein the wireline comprises a slickline.

30

1 14. A wireline according to any of claims 11 to 13,
2 wherein the insulating coating comprises at least one
3 enamel material.

4
5 15. A distance measurement apparatus for measuring
6 the distance travelled by a wireline, the apparatus
7 comprising at least one sensor coupled to the
8 wireline wherein the sensor is capable of sensing
9 known locations in a wellbore.

10
11 16. Apparatus according to claim 15, wherein the
12 wireline is typically a slickline.

13
14 17. Apparatus according to either of claims 15 or
15 16, wherein the apparatus includes transmission means
16 for transmitting data collected by the at least one
17 sensor to a receiver located remotely from the
18 apparatus.

19
20 18. Apparatus according to claim 17, wherein the
21 wireline is capable of acting as an antenna for the
22 transmission means.

23
24 19. Apparatus according to either of claims 17 or
25 18, wherein the sensor is coupled at or near a
26 downhole tool whereby the distance travelled by the
27 tool, and the location of the tool within the
28 wellbore, can be calculated.

29
30 20. Apparatus according to any of claims 17 to 19,
31 wherein the wireline is electrically insulated.

1 21. A method of measuring the distance travelled by
2 a wireline, the method comprising the steps of
3 coupling at least one sensor to the wireline, the at
4 least one sensor being capable of sensing known
5 locations in a wellbore; running the wireline into
6 the wellbore; calculating the depth of the at least
7 one sensor; generating a signal when the at least one
8 sensor passes said known locations; using the signal
9 to calculate a depth correction factor; and
10 correcting the calculated depth using the depth
11 correction factor.

12
13 22. A downhole tool comprising coupling means to
14 allow the tool to be attached to a wireline, at least
15 one sensor capable of detecting known locations in a
16 wellbore and generating a signal indicative thereof,
17 and a transmission means capable of transmitting the
18 signal.

19
20 23. A downhole tool according to claim 20, wherein
21 the wireline acts as an antenna for the transmission
22 means.

23
24 24. A downhole tool according to either of claims 22
25 or 23, wherein the coupling means comprises a rope-
26 socket.

27
28 25. A downhole tool according to claim 24, wherein
29 the rope-socket is provided with signal coupling
30 means to couple the signal generated by the
31 transmission means to the wireline.

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26. A downhole tool according to any of claims 20 to 23, wherein the downhole tool is powered by a DC power supply.

27. A method of tracking a member in a wellbore, the method comprising providing a sensor on the member, inserting the member and sensor into the wellbore, obtaining information indicating the position of the sensor in the wellbore, and determining the distance travelled by said member from said sensor information.

28. Apparatus for indicating the configuration of a downhole tool or tool string, the apparatus comprising at least one sensor capable of sensing a change in the configuration of the downhole tool or tool string and generating a signal indicative thereof, and a transmission means electrically coupled to the at least one sensor for transmitting the signal to a receiver.

29. Apparatus according to claim 28, wherein the downhole tool is preferably suspended in a borehole using a wireline, and the wireline is capable of acting as an antenna for the transmission means.

30. Apparatus according to either of claims 28 or 29, wherein the transmitter facilitates the transmission of data collected by the sensor to the receiver.

1 31. Apparatus according to any of claims 28 to 30,
2 wherein the transmission means comprises a
3 transmitter.
4

5 32. Apparatus according to any of claims 28 to 31,
6 wherein the receiver is located at, or near, the
7 surface of the borehole.
8

9 33. Apparatus according to any of claims 26 to 30,
10 wherein the apparatus is arranged whereby it can
11 facilitate two-way communication between the downhole
12 tool and the receiver.
13

14 34. Apparatus according to any of claims 28 to 32,
15 wherein the sensor comprises an electric or magnetic
16 sensor which is coupled to the downhole tool wherein
17 a discontinuity of the respective electric or
18 magnetic connection triggers at least one signal.
19

20 35. Apparatus according to any of claims 29 to 34,
21 wherein the wireline is electrically insulated.
22

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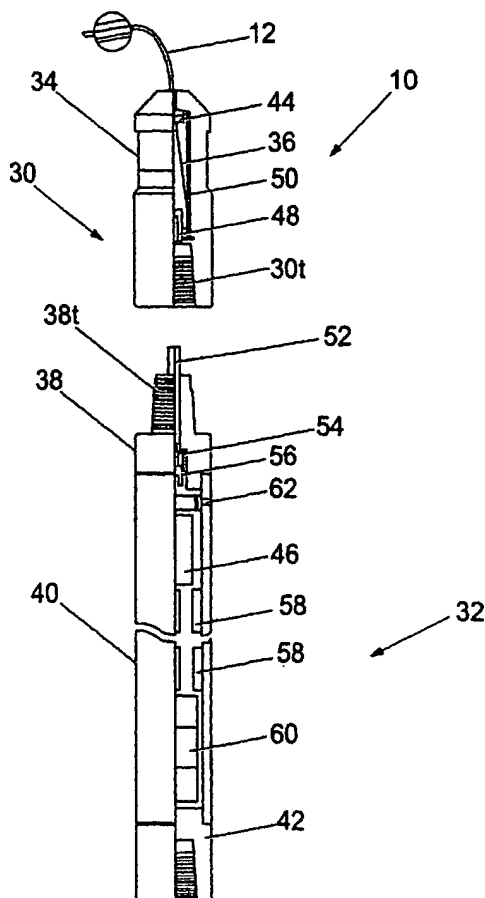
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DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL,
IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU,
LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT,
RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA,
UG, US, UZ, VN, YU, ZA, ZW.

[Continued on next page]

(54) Title: APPARATUS AND METHODS FOR MEASURING DEPTH



(57) Abstract: A communication system for use in a wellbore, a downhole tool, and a method includes a transmitter coupled to a wireline, and a receiver located remotely from the transmitter. The wireline is capable of acting as an antenna for the transmitter. The wireline is a slickline, and the transmitter may be associated with, provided on, or an integral part of a downhole tool or tool string. The transmitter typically transmits data collected or generated by the downhole tool or the like to the receiver, which is preferably located at, or near, the surface of the wellbore. The wireline is typically provided with an insulating coating. Also, a distance measurement apparatus and a method for measuring the distance travelled by a wireline includes at least one sensor coupled to the wireline, and the sensor is capable of sensing known locations in a wellbore.

WO 01/20129 A3



(84) **Designated States (regional):** ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

(88) **Date of publication of the international search report:**
2 August 2001

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Published:

— with international search report

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 E21B47/12 E21B47/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 001 774 A (DAWSON ET AL.) 4 January 1977 (1977-01-04) column 3, line 30 - line 64 column 4, line 19 - line 34	1-13
Y	-----	14, 18, 20, 23, 29, 35
Y	US 4 814 548 A (TRAVERSINO ET AL.) 21 March 1989 (1989-03-21) column 1, line 44 - line 46	14
A	US 3 209 323 A (GROSSMAN) 28 September 1965 (1965-09-28) column 5, line 18 - line 37 ----- -/--	1

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

28 February 2001

Date of mailing of the international search report

06.03.2001

Name and mailing address of the ISA

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Fax: (+31-70) 340-3016

Authorized officer

Rampelmann, K

2

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-14

Communication system

2. Claims: 15-35

Downhole depth measurement system

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 4001774	A	04-01-1977	NONE	
US 4814548	A	21-03-1989	NONE	
US 3209323	A	28-09-1965	NONE	
GB 936461	A		NONE	
US 3267365	A	16-08-1966	NONE	
US 3185997	A	25-05-1965	NONE	
US 4044470	A	30-08-1977	NONE	

REPLACED BY
ART 34 AMDT

38

1 CLAIMS:-

2

3 1. A communication system for use in a wellbore,
4 the system comprising a transmitter coupled to a
5 wireline, and a receiver located remotely from the
6 transmitter, wherein the wireline is capable of
7 acting as an antenna for the transmitter.

8

9 2. An apparatus according to claim 1, wherein the
10 wireline is a slickline.

11

12 3. An apparatus according to either of claims 1 or
13 2, wherein the transmitter is associated with,
14 provided on, or an integral part of a downhole tool
15 or tool string.

16

17 4. An apparatus according to claim 3, wherein the
18 downhole tool or tool string is suspended by the
19 wireline.

20

21 5. An apparatus according to either of claims 3 or
22 4, wherein the transmitter transmits data collected
23 or generated by the downhole tool or the like to the
24 receiver.

25

26 6. An apparatus according to any preceding claim,
27 wherein the receiver is located at, or near, the
28 surface of the wellbore.

29

30 7. An apparatus according to any preceding claim,
31 wherein the transmitter is coupled to the wireline at

1 or near a downhole tool whereby the distance
2 travelled by the tool, the status of the tool or
3 other parameters of the tool, can be transmitted to
4 the receiver.

5

6 8. Apparatus according to any preceding claim,
7 wherein the wireline is electrically insulated.

8

9 9. Apparatus according to any preceding claim,
10 wherein the wireline is sheathed to facilitate
11 electrical insulation.

12

13 10. A method of communication in a wellbore,
14 comprising providing a transmitter coupled to a
15 wireline, paying an end of the wireline and the
16 transmitter into the wellbore, and providing a
17 receiver located remotely from the transmitter, such
18 that the wireline acts as an antenna for the
19 transmitter.

20

21 11. A wireline for use in a wellbore, wherein the
22 wireline is provided with an insulating coating.

23

24 12. A wireline according to claim 11, wherein the
25 insulating coating is an outer coating of the
26 wireline.

27

28 13. A wireline according to either of claims 11 or
29 12, wherein the wireline comprises a slickline.

30

1 14. A wireline according to any of claims 11 to 13,
2 wherein the insulating coating comprises at least one
3 enamel material.

4
5 15. A distance measurement apparatus for measuring
6 the distance travelled by a wireline, the apparatus
7 comprising at least one sensor coupled to the
8 wireline wherein the sensor is capable of sensing
9 known locations in a wellbore.

10
11 16. Apparatus according to claim 15, wherein the
12 wireline is typically a slickline.

13
14 17. Apparatus according to either of claims 15 or
15 16, wherein the apparatus includes transmission means
16 for transmitting data collected by the at least one
17 sensor to a receiver located remotely from the
18 apparatus.

19
20 18. Apparatus according to claim 17, wherein the
21 wireline is capable of acting as an antenna for the
22 transmission means.

23
24 19. Apparatus according to either of claims 17 or
25 18, wherein the sensor is coupled at or near a
26 downhole tool whereby the distance travelled by the
27 tool, and the location of the tool within the
28 wellbore, can be calculated.

29
30 20. Apparatus according to any of claims 17 to 19,
31 wherein the wireline is electrically insulated.

1 21. A method of measuring the distance travelled by
2 a wireline, the method comprising the steps of
3 coupling at least one sensor to the wireline, the at
4 least one sensor being capable of sensing known
5 locations in a wellbore; running the wireline into
6 the wellbore; calculating the depth of the at least
7 one sensor; generating a signal when the at least one
8 sensor passes said known locations; using the signal
9 to calculate a depth correction factor; and
10 correcting the calculated depth using the depth
11 correction factor.

12

13 22. A downhole tool comprising coupling means to
14 allow the tool to be attached to a wireline, at least
15 one sensor capable of detecting known locations in a
16 wellbore and generating a signal indicative thereof,
17 and a transmission means capable of transmitting the
18 signal.

19

20 23. A downhole tool according to claim 20, wherein
21 the wireline acts as an antenna for the transmission
22 means.

23

24 24. A downhole tool according to either of claims 22
25 or 23, wherein the coupling means comprises a rope-
26 socket.

27

28 25. A downhole tool according to claim 24, wherein
29 the rope-socket is provided with signal coupling
30 means to couple the signal generated by the
31 transmission means to the wireline.

1
2 26. A downhole tool according to any of claims 20 to
3 23, wherein the downhole tool is powered by a DC
4 power supply.

5
6 27. A method of tracking a member in a wellbore, the
7 method comprising providing a sensor on the member,
8 inserting the member and sensor into the wellbore,
9 obtaining information indicating the position of the
10 sensor in the wellbore, and determining the distance
11 travelled by said member from said sensor
12 information.

13
14 28. Apparatus for indicating the configuration of a
15 downhole tool or tool string, the apparatus
16 comprising at least one sensor capable of sensing a
17 change in the configuration of the downhole tool or
18 tool string and generating a signal indicative
19 thereof, and a transmission means electrically
20 coupled to the at least one sensor for transmitting
21 the signal to a receiver.

22
23 29. Apparatus according to claim 28, wherein the
24 downhole tool is preferably suspended in a borehole
25 using a wireline, and the wireline is capable of
26 acting as an antenna for the transmission means.

27
28 30. Apparatus according to either of claims 28 or
29 29, wherein the transmitter facilitates the
30 transmission of data collected by the sensor to the
31 receiver.

1 31. Apparatus according to any of claims 28 to 30,
2 wherein the transmission means comprises a
3 transmitter.

4

5 32. Apparatus according to any of claims 28 to 31,
6 wherein the receiver is located at, or near, the
7 surface of the borehole.

8

9 33. Apparatus according to any of claims 26 to 30,
10 wherein the apparatus is arranged whereby it can
11 facilitate two-way communication between the downhole
12 tool and the receiver.

13

14 34. Apparatus according to any of claims 28 to 32,
15 wherein the sensor comprises an electric or magnetic
16 sensor which is coupled to the downhole tool wherein
17 a discontinuity of the respective electric or
18 magnetic connection triggers at least one signal.

19

20 35. Apparatus according to any of claims 29 to 34,
21 wherein the wireline is electrically insulated.

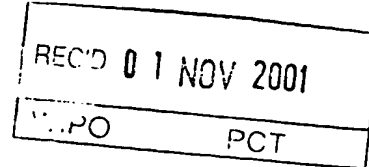
22

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)





14

Applicant's or agent's file reference P23959A/MGO/JDB	FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/GB00/03491	International filing date (day/month/year) 12/09/2000	Priority date (day/month/year) 14/09/1999
International Patent Classification (IPC) or national classification and IPC E21B47/12		
Applicant MACHINES (U.K.) LIMITED et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 11 sheets, including this cover sheet.
- ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).
- These annexes consist of a total of 6 sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☒ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☒ Certain defects in the international application
- VIII ☒ Certain observations on the international application

Date of submission of the demand 12/04/2001	Date of completion of this report 30.10.2001
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Str mmen, H Telephone No. +49 89 2399 7345 

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB00/03491

I. Basis of the report

1. With regard to the **elements** of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17)*):

Description, pages:

1-37 as originally filed

Claims, No.:

1-35 as received on 11/10/2001 with letter of 11/10/2001

Drawings, sheets:

1/5-5/5 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB00/03491

- ☐ the drawings, sheets:
5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):
(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

IV. Lack of unity of invention

1. In response to the invitation to restrict or pay additional fees the applicant has:
- ☐ restricted the claims.
- ☐ paid additional fees.
- ☐ paid additional fees under protest.
- ☐ neither restricted nor paid additional fees.
2. ☒ This Authority found that the requirement of unity of invention is not complied and chose, according to Rule 68.1, not to invite the applicant to restrict or pay additional fees.
3. This Authority considers that the requirement of unity of invention in accordance with Rules 13.1, 13.2 and 13.3 is
- ☐ complied with.
- ☐ not complied with for the following reasons:
4. Consequently, the following parts of the international application were the subject of international preliminary examination in establishing this report:
- ☒ all parts.
- ☐ the parts relating to claims Nos. .

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-9, 14, 26, 33
	No:	Claims	10-13, 15-25, 27-32, 34-35
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-35

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. PCT/GB00/03491

Industrial applicability (IA) Yes: Claims 1-35
 No: Claims

2. Citations and explanations
see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

Reference is made to the following documents:

- D1: US-A-4 001 774
- D2: US-A-3 267 365
- D3: US-A-3 185 997
- D4: US-A-3 209 323

Re Item IV

Lack of unity of invention

IV-1 Even though none of the independent claims seem to meet the requirements of Article 33(2) or (3) PCT, this International Examining Authority confirms the founding of the International Searching Authority concerning the presence of two groups of inventions in the present application. Said two groups of inventions can be identified as follows:

1. Claims 1-14: Communication system
2. Claims 15-35: Downhole depth measurement system

The "special technical feature" (in the meaning of Rule 13.2 PCT) of the first group of inventions is that the wireline serves as a telemetry link between communications equipment located downhole and communications equipment located topsides. The problem solved by said feature is to provide a way of communication between said mutually remote locations.

The "special technical feature" (in the meaning of Rule 13.2 PCT) of the second group of inventions is to provide depth information for equipment travelling up or down a well by referencing to known locations in said well. The problem solved is therefore how to know the actual travelled distance of a piece of equipment that has been placed inside a well.

The "special technical feature" of the two groups of inventions are therefore different and solve different problems so that no technical relationships can be seen among them. According to Rule 13.2 PCT, the application does therefore not meet the requirement of Rule 13.1 PCT.

Re It m V

Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

V-1 D1, which is considered the closest prior art, discloses the subject-matter of claim 1 as follows (the references in parentheses applying to this document):

A communication system for use in a wellbore (col. 1, l. 9-12), the system comprising a downhole tool (21), the downhole tool (21) comprising a transmitter (col. 3, l. 56), the downhole tool (21) being coupled to a wireline (40), wherein the downhole tool (21) and wireline (40) are adapted to be inserted into the wellbore (17), and a receiver (28) located remotely from the transmitter (see fig. 1), wherein the wireline (40) is capable of acting as an antenna for the transmitter (col. 3, l. 57-58).

The apparatus according to claim 1, therefore differs with respect to D1 in that the wireline is also capable of running the downhole tool into the wellbore.

The apparatus according to claim 1 is therefore new and the claim meets the novelty requirements of Article 33(2) PCT.

V-2 The distinguishing feature of claim 1 is thus related the problem of how to more efficiently deploy a device or downhole tool into a wellbore.

In particular, in view of D4, fig. 1, said distinguishing feature of claim 1 does not involve an inventive step in the meaning of Article 33(3) PCT. It is considered obvious that the skilled man would adapt the teaching from D4 into D1 in order to solve the problem.

V-3 Furthermore, D1 discloses the subject-matter of the following claims:

Claim 2: see col. 4, l. 23-24

Claim 3: see fig. 1, item 21

Claim 4: see fig. 1, item 40

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EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/GB00/03491

Claim 5: see col. 3, l. 43-46

Claim 6: see fig. 1, item 28

Claim 7: see col. 3, l. 33-39

Claim 8: see col. 3, l. 58-59

Claim 9: see col. 4, l. 23-24

The subject-matter of said claims does therefore not involve an inventive step (Article 33(3) PCT).

V-4 With respect to independent claim 10, and in addition to what has already been said under section V-1, D1 in fig. 1 furthermore discloses that a wireline 40 including its ends with a transmitter 21 attached to the one of said ends, has in one way or another been payed into the borehole 17. See also col. 4, l. 27-34.

Said claim does therefore not meet the novelty requirements of Article 33(2) PCT in that the claim is not new over D1.

V-5 Also independent claim 11 as well as dependent claims 12 and 13 do not seem to contain novel subject-matter over D1 (see col. 4, l. 19-26). Said claims do therefore not meet the novelty requirements of Article 33(2) PCT).

V-6 The subject-matter of dependent claim 14 is consider an obvious design alternative for the skilled man when solving the problem of insulation material selection. Said claim does therefore not involve an inventive step (Article 33(3) PCT).

V-7 D2 discloses the subject-matter of claim 15 as follows (the references in parentheses applying to this document):

A distance measurement apparatus (fig. 1) for measuring the distance travelled by a wireline (17), the apparatus (fig. 1) comprising at least two sensors (fig. 6, item 64, 65) coupled to the wireline (17) wherein the sensors (64, 65) are capable of sensing known locations (15) in a wellbore (11).

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/GB00/03491

The subject-matter of claim 15 is therefore not new contrary to the provisions of Article 33(2) PCT.

The applicants attention is drawn to the fact that even if D2 did not disclose a plurality of sensors, claim 15 would not be considered as involving an inventive step in the meaning of Article 33(3) PCT by just limiting the possible number of sensors to the system.

V-8 Furthermore, D2 discloses the subject-matter of claim 16 as any line can be seen as a slick line. Claim 16 is therefore not new (Article 33(2) PCT). See also section VIII-3.

V-9 Furthermore, D2 discloses the subject-matter of the following claims:

Claim 17: see fig. 1, item 56

Claim 18: see fig. 1, item 17

Claim 19: see col. 3, l. 48-52

Claim 20: see col. 2, l. 47

The subject-matter of said claims is therefore not new (Article 33(2) PCT).

V-10 Also the subject-matter of independent claim 21 and 22 is disclosed by D2. See in particular fig. 1 of D2. Refer also to sections V-5 above.

The subject-matter of claims 21 and 22 is therefore not new contrary to the provisions of Article 33(2) PCT.

V-11 Furthermore, D2 discloses the subject-matter of the following claims:

Claim 23: see fig. 1, item 17, where the cable 17 can be said to act as an antenna, i.e. the medium upon which the signal is transferred to the recorder 56.

Claim 24: see fig. 1, the socket is part of the arrangement referred to as 21.

**INTERNATIONAL PRELIMINARY
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International application No. PCT/GB00/03491

Claim 25: as the signal is clearly going from the sensor 50 to cable 17, the socket must include means to expedite the signal through the socket.

The subject-matter of said claims is therefore not new (Article 33(2) PCT).

V-12 Claim 26 does not involve an inventive step (Article 33(3) PCT). See D3, fig. 3, item 30.

V-13 Independent method claim 27 relates effectively to the same subject-matter as independent claim 21 and does therefore also not meets the requirements of Article 33(2) PCT.

V-14 As far as claim 28 can be understood, said claim relates effectively to the same subject-matter as independent claim 21 and does therefore also not meets the requirements of Article 33(2) PCT. See also section VIII-2.

V-15 What has been said about claim 23 applies also to claim 29. The subject-matter of said claims is therefore not new (Article 33(2) PCT).

V-16 Furthermore, at least D2 discloses the subject-matter of the following claims:

Claim 30: see col. 4, l. 48-52

Claim 31: see col 5, l. 30-32

Claim 32: see fig. 1, item 56

Claim 34: see col 4, l. 40-52

Claim 35: see: col. 2, l. 47

The subject-matter of said claims is therefore not new (Article 33(2) PCT).

V-17 With respect to claim 33, it is considered as normal practice, in the industry, to select between the features of having one-way or two-way communication between two stations, when designing a telemetry link. said claim does therefore not involve an inventive step (Article 33(3) PCT).

Re Item VII

Certain defects in the international application

- VII-1 The independent claims are not in the two-part form in accordance with Rule 6.3(b) PCT, which in the present case would be appropriate, with those features known in combination from D1-D2 being placed, where appropriate, in the preamble (Rule 6.3(b)(i) PCT) and with the remaining features being included in the characterising part (Rule 6.3(b)(ii) PCT).
- VII-2 The features of the claims are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT).
- VII-3 Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in D1-D4 is not mentioned in the description, nor are these documents identified therein.

Re Item VIII

Certain observations on the international application

- VIII-1 To satisfy the conciseness requirement of Article 6 PCT, the present set of claims should include only the minimum necessary number of independent claims in any one category. Said requirement is not satisfied by any of the independent claims, as in the present case, it is considered appropriate to use only one independent claim in any one category.
- VIII-2 Claim 28 is not clear (Article 6 PCT) in that it can not be determined if the "configuration of the downhole tool or tool string", as specified in the claim, refers to the location of the tool in the borehole or if it refers to the composition of the casing as such, alternatively to the tool string being run inside the casing.
- VIII-3 At least claims 2, 13 and 16 do not meet the requirements of Article 6 PCT in that the matter for which protection is sought is not clearly defined as the term "slickline" does not univocally imply any specific structural feature. The claim attempts therefore to define the subject-matter in terms of the result to

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/GB00/03491

be achieved which merely amounts to a statement of the underlying problem. The technical features necessary for achieving this result should be added.

INTERNATIONAL SEARCH REPORT

Int. Application No

PCT/GB 00/03491

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 E21B47/12 E21B47/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 001 774 A (DAWSON ET AL.) 4 January 1977 (1977-01-04) column 3, line 30 - line 64 column 4, line 19 - line 34	1-13
Y		14, 18, 20, 23, 29, 35
Y	US 4 814 548 A (TRAVERSINO ET AL.) 21 March 1989 (1989-03-21) column 1, line 44 - line 46	14
A	US 3 209 323 A (GROSSMAN) 28 September 1965 (1965-09-28) column 5, line 18 - line 37	1
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☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

° Special categories of cited documents :

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

- *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- *&* document member of the same patent family

Date of the actual completion of the international search

28 February 2001

Date of mailing of the international search report

06.03.2001

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INTERNATIONAL SEARCH REPORT

Int. Application No

PCT/GB 00/03491

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 936 461 A (TROSZT) 11 September 1963 (1963-09-11) page 3, line 27 - line 39 page 3, line 79 - line 91 page 4, line 49 - line 57 claim 1	15-17, 19,22, 24,25, 27,28, 30,32-34
Y		14,18, 20,23, 29,35
X	US 3 267 365 A (BAKER) 16 August 1966 (1966-08-16) column 1, line 29 - line 35 column 4, line 34 -column 5, line 39	15-17, 19,22, 24,25, 27,28, 30,32,34
X	US 3 185 997 A (CARLTON ET AL.) 25 May 1965 (1965-05-25) column 1, line 40 - line 42 column 2, line 32 - line 43 column 2, line 63 -column 3, line 42	15,16, 21,22, 26-28,34
X	US 4 044 470 A (DUFRENE) 30 August 1977 (1977-08-30) column 4, line 35 - line 68	22,24

INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB 00/03491

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-14

Communication system

2. Claims: 15-35

Downhole depth measurement system

INTERNATIONAL SEARCH REPORT

Information on patent family members

Int. Patent Application No

PCT/GB 00/03491

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4001774 A	04-01-1977	NONE	
US 4814548 A	21-03-1989	NONE	
US 3209323 A	28-09-1965	NONE	
GB 936461 A		NONE	
US 3267365 A	16-08-1966	NONE	
US 3185997 A	25-05-1965	NONE	
US 4044470 A	30-08-1977	NONE	